

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,295,594

January 3, 1967

James H. Hopper

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, after line 11, insert the following paragraph.

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U. S. C. 2457).

Signed and sealed this 3rd day of October 1967.

(SEAL)
Attest:

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JUN 7 1982

Reply to Attn of: GP-4

TO: NST-44/Scientific and Technical Information Division
Attn: Shirley Peigare

FROM: GP-4/Office of Assistant General Counsel
for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP-4 and Code NST-44, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,295,594
Government or Contractor Employee: United Technologies Corp.
Hartford, CT
NASA Case No. : XMS-03,694-1

NOTE - If this patent covers an invention made by a contractor employee under a NASA contract, the following is applicable:

YES ☒

NO ☐

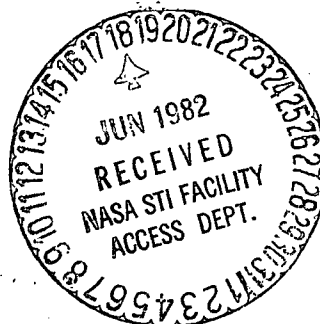
Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the specification, following the words "...with respect to an invention of...."

(NASA-Case-XMS-03694-1)
Patent (NASA) 6 p

THERMAL GARMENT
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N82-29002

Unclas
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3,295,594 THERMAL GARMENT

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10 Claims. (Cl. 165—46)

This invention relates to thermal garments and more particularly to thermal garments which are made entirely of tubing.

It is an object of this invention to teach a thermal garment and the method of manufacture thereof, or a portion of a thermal garment, which is made entirely of fluid carrying tubing joined in such a way that the tubes form a network or mesh fabric which is expandable and flexible such that the garment will conform to the contours of the human body and such that all tubes lie against the body of the occupant at all times. A thermal garment which precisely assumes and maintains the human form of the occupant is said to be anthropomorphic.

It is a further object of this invention to teach a thermal garment which is made entirely of flexible tubing including an intake and an outlet header or manifold and a plurality of individual tubes running therebetween and joined together in serpentine or sinusoidal fashion so that the network made of the tubing is both flexible, expandable or stretchable and retractable or contractable and so that such tubing is of sufficient strength that it will not be flattened when sat upon or otherwise brought under pressure by the space suit occupant.

It is a further object of this invention to teach a thermal suit made entirely of tubes and in which each tube forms a separate fluid channel from all other tubes.

It is still a further object of this invention to teach a thermal garment or a partial thermal garment which is made entirely of joined tube pairs, which tube pairs are so joined that one such joined tube remains free running at all times.

Other objects and advantages will be apparent from the specification and claims and from the accompanying drawings which illustrate an embodiment of the invention.

FIG. 1 is a schematic representation of the system for providing fluid to a thermal garment.

FIG. 2 is a showing of a thermal garment portion made entirely of tubes and including inlet and outlet tube headers or manifolds.

FIG. 3 is a section taken along line 3—3 of FIG. 2 to show adjacent tubes joined in side-by-side relation.

FIG. 4 is a showing of a human body to illustrate how a thermal garment made in the fashion taught herein could be used.

FIG. 5 is a modification of my thermal garment construction showing how single tubes may be forked into double tubes and so forth.

FIG. 6 is a perspective showing taken from the position of the occupant's body to show the support and connection between the thermal tubes and the thermal manifolds.

FIG. 7 is a modification to the connection between adjacent thermal tubes and is an alternate to the type of connection shown in FIG. 3.

FIG. 8 is a thermal partial garment for use on the torso of the occupant.

FIG. 9 is a partial showing of a plurality of thermal tubes interconnected and in their unexpanded or retracted positions.

Referring to FIG. 1 we see a schematic representation of the support system for a thermal garment. A thermal garment, which may be used either to heat or cool the garment occupant, must be provided fluid, such as water, anti-freeze or the like, at the proper temperature, pres-

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sure and flow rate to be able to properly perform its function. The portable fluid providing system 10 of FIG. 1 comprises pump 12 which pumps the fluid through conduit 14 into conventional heat exchanger 16, where the fluid is brought to the proper temperature. Upon leaving heat exchanger 16, the fluid passes through conduit 18 and into garment or garment portion 20, from whence it is passed through conduit 22 back to pump 12 for recirculation.

It is an important teaching of this invention that the thermal garment or thermal garment portion be made entirely of thermal tubing and be joined in such a fashion that the web, net, mesh fabric or network formed by the tubing is resilient, flexible and expandable so that it will lie flat against the body of the occupant and conform readily to the contours of the occupant's body whether the occupant is still or moving. The thermal garment is accordingly said to be anthropomorphic.

The preferred garment construction is illustrated in FIG. 2, which includes inlet manifold tubing 24, which receives thermal fluid from conduit 18 and also includes a plurality of thermal tubes 26 which extend between intake or inlet manifold or header tubing 24 and outlet or scavenge manifold or header tubing 28. Conduit 22 projects from outlet manifold tubing 28 to permit the return of the thermal fluid from garment 20 to pump 12 as illustrated in FIG. 1. Tubes 24, 26 and 28 are of conventional hollow construction and are joined by molding, gluing or any conventional type of connection such that the interior of each tube 26 is in communication with the interior of both tube 24 and tube 28. Accordingly, thermal fluid from tube 24 will flow into and through each tube 26 and then, from each tube 26, into tube 28 where it is returned through conduit 22 to pump 12. So that the garment or fabric 20 will lie flat against and remain in contact with the surface of the occupant's body at all times, tubes 26 are joined at spaced points or stations in sinusoidal or serpentine fashion as illustrated in FIG. 2. Adjacent tubes 26a and 26b; and 26c and 26d are joined by clips 30 to form tube pairs 32. Clips 30 preferably lie in a single plane parallel to manifold tube 24. Then, adjacent tubes of adjacent tube pairs 32, such as 26b and 26c; and 26d and 26e, are joined by clips 34 at a second planar station parallel to the first planar station of clips 30. Adjacent tubes such as 26a and 26b; and 26c and 26d are then joined by clips 36 at a third planar station parallel to the planar stations of clips 34 and 30, thereby beginning the recycling of the tube joining process.

FIG. 3 illustrates a cross-sectional showing of clip 34, and it should be borne in mind that clips 30 and 36 are identical therewith. Clip 34, which is presumably a plastic clip, joins tubes 26d and 26e and is preferably attached to one such tube, such as 26e but the other such tube, such as 26d is free running within clip 34 so as to add to the flexibility and expandability of the network 20 so that it will more readily follow the contours of the occupant's body and lie flat thereagainst. Clips 30, 34 and 36 join the tubes 26 in side-by-side relation thereby avoiding tube overlapping and the attendant displacement of the tubes 26 from the occupant's body. Since the tubes 26d and 26e are joined in free-running relation within clip 34, these tubes will be restrained from moving laterally with respect to each other but are free to move longitudinally with respect to each other thereby permitting the space garment so fabricated to follow the contours of the wearer's body as the wearer moves about, thereby making the garment anthropomorphic.

It will be noted that plastic tape 35 extends over and between the knife-like edges 37 and 38 of clip 34 and bears against the body of the space suit occupant. Tape 35 is about .004" thick and is a good thermal conductor.

FIG. 7 illustrates another manner in which tubes 26

may be joined. FIG. 7 shows vinyl sleeve 39 encircling adjacent tubes 26 and is preferably attached to one said tube as at point 41, while the other tube is free running.

Snap 40 serves to join the edges of the thermal garment together or the edges of adjacent thermal garment portions together. For example, as best shown in FIG. 2, snap 40 may join tube 26e of thermal garment 20 to tube 42 of the adjacent thermal garment portion.

Snap 40 comprises male snap member 43 and female snap member 45, each of which are attached to a circular grommet (not shown) which surrounds tube 26.

It is deemed advisable to support tubes 26 adjacent their point of connection to manifolds 24 and 28 and, therefore, it is recommended that webbing or a belt 51 (FIG. 6) be placed outside of tubes 26 and include grip members 53, which surround and support tubes 26 adjacent their connection to the manifolds 24 and/or 28.

It will be evident to those skilled in the art that tube 42 could as well be the end tube of garment 20 when garment 20 is to be used on a human appendage such as a leg and tubes 42 and 26e will be joined by clips or snaps 40 when garment 20 is wrapped around the occupant's leg and joined by clips or snaps 40 in legging fashion.

By viewing FIG. 2 it will be noted that each tube 26 is joined alternately to the adjacent tubes on opposite sides thereof. For example, tube 26c is first joined to tube 26d then to tube 26b, then to tube 26d and so on so that each tube, such as 26c forms a sinusoidal or serpentine pattern and so that voids 44 are formed between adjacent tubes 26.

FIG. 9 illustrates a plurality of tubes 26 joined by clips 30, 34 and 36 and lying substantially parallel to one another in their unexpanded or retracted position. This is the position which the tubes will be in before they are expanded at their opposite ends to connect to manifolds 24 and 28 and before they are expanded at their central positions and held in that expanded position by snaps 40 as they cover the body or a portion of the body of the space suit occupant.

Referring to FIG. 4 we see thermal garment 20 on a human body. Thermal garment 20, in the FIG. 4 configuration, is made in four sections, namely, the left leg section 46, the right leg section 48, the left torso and left arm section 50 and the right torso and right arm section 52. Considering left leg portion 46 as typical, inlet manifold 24 may be positioned around the ankle thereof while outlet manifold 28 is preferably around the suit occupant's waist. The respective positions of the inlet and outlet manifold could obviously be changed; however, for convenience, it will probably be advisable to bring garment inlet tube 18 of FIG. 1 to the occupant at waist level and to position outlet conduit 22 of FIG. 1 at waist level also. It will accordingly be necessary to run either conduit 18 or 22 the length of the space suit occupant's leg to bring either the incoming or scavenging thermal fluid to or from the ankle area.

Considering left torso and left arm section 50, the inlet manifold 24 may be at the occupant's waist, while outlet manifold 28 is at the wrist, or vice versa, but in all instances inlet and outlet tubes 18 and 22, respectively, should be brought in at space suit occupant's waist.

FIG. 8 illustrates a garment portion made in accordance with my invention. Thermal tubes 26 extend from inlet manifold 24, which extends across the front waist of the occupant, up the front of the torso of the occupant, across his shoulders, then down the back torso of the occupant to outlet manifold 28 (not shown) which extends across the back waist of the occupant. Snaps 40 preferably join the garment edges along the sides.

Referring to FIG. 5 we see a modification of garment 20 in which tubes 26a-d are joined as in FIG. 2, first at clips 30 then at clips 34, then at clips 36, but thereafter each tube 26 forks into two tubes, for example, tube 26a

forks into tubes 60 and 62 while tube 26b forks into tube 64 and 66.

It will be evident to those skilled in the art that tubes 24, 26 and 28 may be made of several different types of material each of which are non-absorbent and non-porous but it is preferable that the material be a good heat conductor. Tubes 24-28 could be made of rubber or plastic and a garment has been so fabricated using a polyvinylchloride as the tube material. For tubes 26, polyvinyl chloride of $\frac{1}{8}$ " O.D. and $\frac{1}{16}$ " I.D. has been found to be quite satisfactory. It will be evident that tubes 24-28 can be of circular cross section or other oval type cross section so as to provide greater heat transfer surfaces against the body of the space suit occupant.

During space suit use, water at 10-20 p.s.i.g. would be provided to garment 20 at temperatures between 32° F. and 80° F. and at flow rates of four pounds per minute down to two pounds per minute.

While, in the preferred embodiment, clips 30-36 are preferably as shown in FIG. 3, it should be borne in mind that rings of polyethylene or glued joints could be substituted therefor.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described but may be used in other ways without departure from its spirit as defined by the following claims.

I claim:

1. An anthropomorphic thermal garment made entirely of tubes and adapted to cover a portion or the entire body of the occupant and comprising a first header-type tube, a second header-type tube, a plurality of third tubes each extending between said first and second tubes and with the interiors of said third tubes communicating with the interior of said first and second tubes, means to gather and retain adjacent third tubes together in side-by-side and free-running relation to thereby form tube pairs so that said third tubes so gathered and joined are restrained from lateral movement with respect to each other but are free to move longitudinally with respect to each other, and means to gather and retain adjacent tubes of said tube pairs together in side-by-side and free-running relation so that said tubes of said tube pairs so gathered and joined are restrained from lateral movement with respect to each other but are free to move longitudinally with respect to each other at selected second stations between said first stations to thereby form a flat, flexible, expandable network.

2. Apparatus according to claim 1 and including means to pass fluid through the interior of said tubes.

3. Apparatus according to claim 1 wherein said fluid passing means includes pumping means to pump fluid into said first tube, then through said second tubes, then through said third tube and back to said pumping means.

4. Apparatus according to claim 3 and including heat exchanger means within said fluid pumping means.

5. Apparatus according to claim 1 wherein one of said third tubes forks into at least two tubes.

6. An anthropomorphic thermal garment made entirely of tubes and adapted to cover a portion or the entire body of the occupant and comprising a plurality of hollow, flexible tubes, and means to join adjacent tubes at selected stations, said joining means being of thin-walled construction and shaped to at least partially envelope the adjacent tubes joined thereby so that the adjacent tubes so joined are in side-by-side relation within the joining means and with at least one of the adjacent tubes so joined being free running through the joining means so that said adjacent tubes so joined are restrained from lateral movement with respect to each other and are free to move longitudinally with respect to each other to thereby form a flat, flexible, expandable tube network, and means to supply fluid to said hollow tubes.

7. Apparatus according to claim 6 wherein the interior of each of said tubes is independent of the interior of

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all other tubes throughout the length thereof so that each tube forms a separate fluid channel.

8. Apparatus according to claim 7 and including an inlet header joined to one end of said tubes and an outlet header joined to the other end of said tubes so that said tubes extend between said headers in single-pass fashion.

9. A thermal garment comprising a plurality of flexible tubes which are parallel and separated at a first substantially planar station and which have adjacent tubes joined in side-by-side and free-running relation so that said adjacent tubes so joined are restrained from lateral movement with respect to each other but are free to move longitudinally with respect to each other at a second substantially planar station substantially parallel to said first substantially planar station thereby forming tube pairs, and further having adjacent tubes of adjacent tube pairs joined in side-by-side and free-running relation so that said adjacent tubes of said adjacent tube pairs are restrained from lateral movement with respect to each other but are free to move longitudinally with respect to each other at a third substantially planar station substantially parallel to said first and second substantially planar stations, thereby forming a flat, flexible, expandable mesh fabric, and means to supply fluid to said hollow tubes.

10. An anthropomorphic thermal garment made entirely of tubes and adapted to cover a portion or the entire

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body of the occupant and comprising a plurality of flexible, hollow tubes, means joining adjacent tubes in side-by-side, free-running relation so that said adjacent tubes so joined are restrained from lateral movement with respect to each other but are free to move longitudinally with respect to each other at selected stations to form a flexible, expandable layer of fabric adapted to lie flat against the occupant's body, and means to supply fluid to said hollow tubes.

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THERMAL GARMENT

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3 Sheets-Sheet 1

FIG. 1

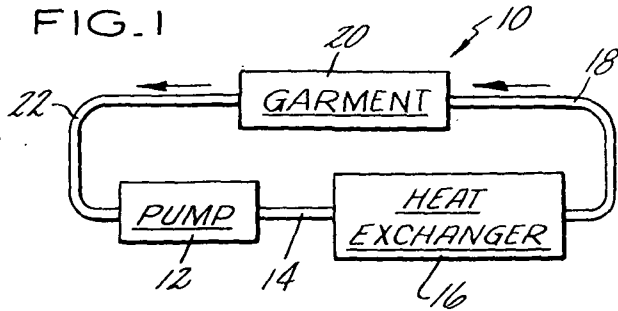


FIG. 4

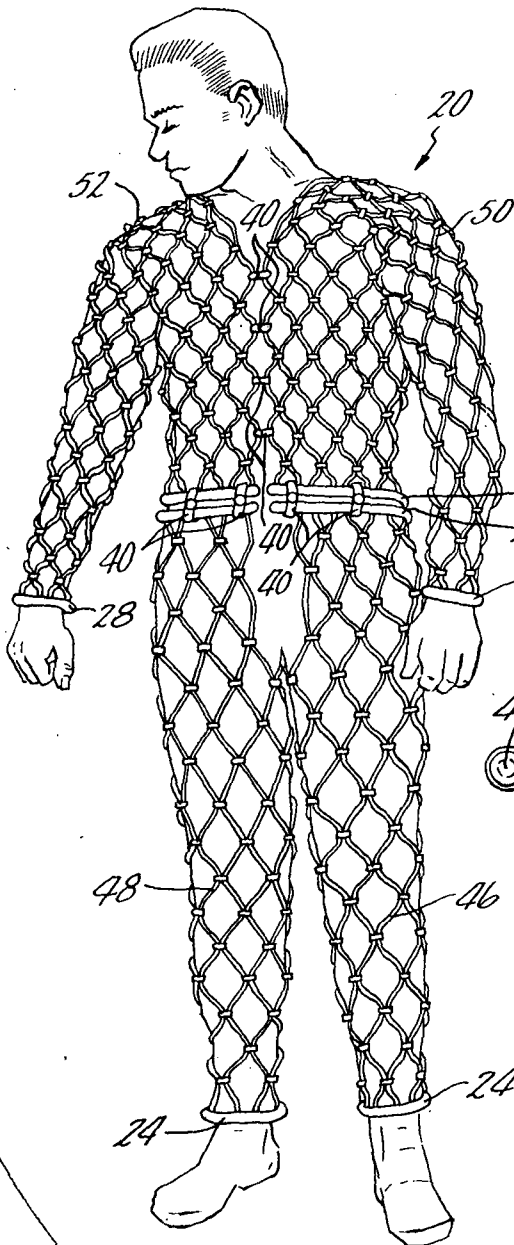


FIG. 3

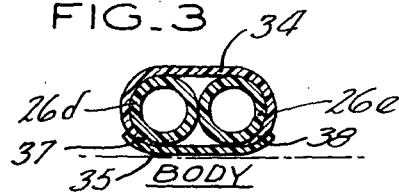
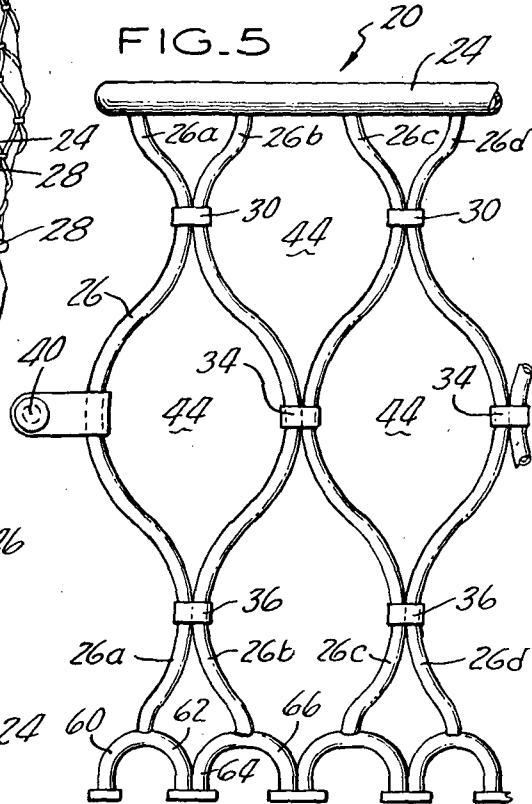


FIG. 5



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FIG. 6

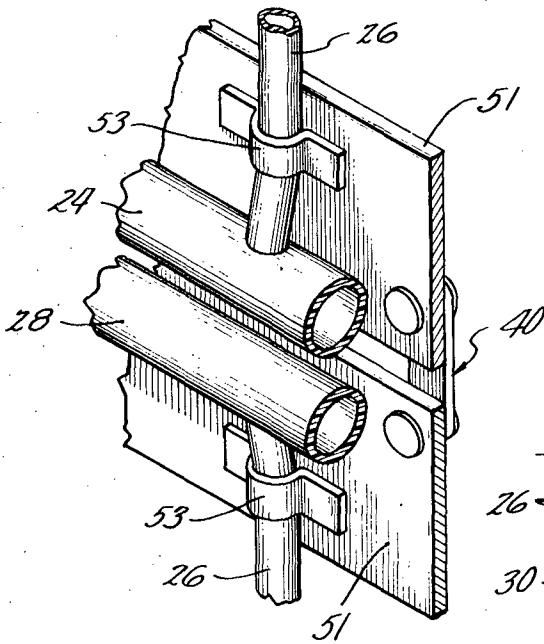


FIG. 7

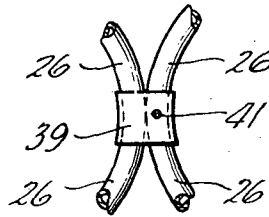


FIG. 9

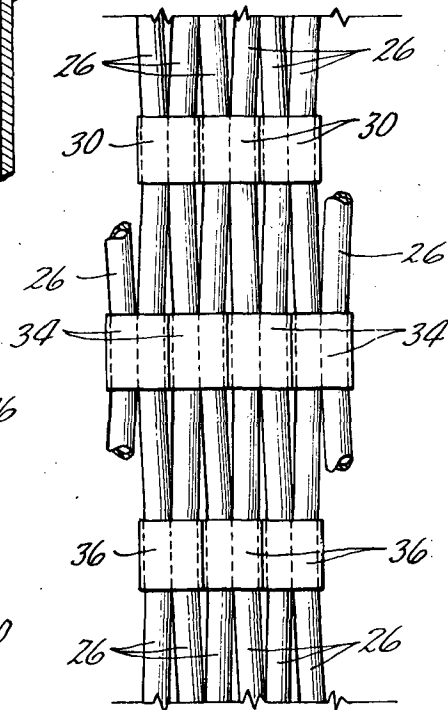
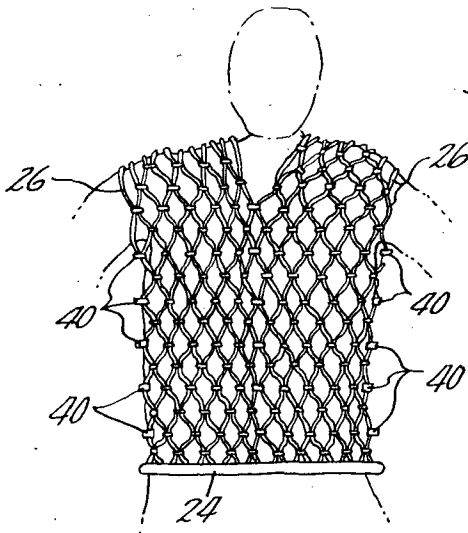


FIG. 8



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